

Original Article

Fractional CO₂ laser in the treatment of atrophic scars

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Received: 5-04-2016/ Revised: 10-04-2016 / Accepted: 25-05-2016

Abstract

A variety of treatment modalities have been used depending on the scar type. Treatment methods may be invasive /or conservative. To assess the efficacy of fractional CO₂ laser in the treatment of atrophic scars. This is an observational study of 30 patients (skin types III–IV, aged 18 –44 years) with atrophic acne and post traumatic depressed scars who underwent three sessions with a fractional CO₂ laser at 1-month interval. Side effects as well as improvements in texture, atrophy and overall satisfaction with appearance were graded on a quartile scale by the patients and investigators after each treatment and 4 weeks after the final treatment. Before–after scores were compared using the student *t*-test, with significance assigned to *P* values less than 0.05. All patients showed clinical improvement. There was a significant difference in the overall scar appearance between both scar groups according to all dermatologists. The acne scar group improved more than the depressed scar group. There was no statistically significant difference in the assessment of the three dermatologists. In terms of patient satisfaction for the acne scars group, 5 patients were slightly satisfied, 2 patients were satisfied, 4 patients were very satisfied and 3 patients were extremely satisfied. The depressed scar group, 3 patients were not satisfied with the outcome, 6 patients were slightly satisfied, 6 patients were satisfied and only 1 patient was extremely satisfied. Side effects were minimal and transient.

Fractional CO₂ laser treatment is a safe, well-tolerated and effective treatment modality for atrophic scars, with minimal downtime and fewer side effects.

Key Words: atrophic acne scars, fractional CO₂ laser, post-traumatic depressed scars

Introduction

The term “Pathologic scarring” is defined as not only an experience of symptoms of pain, urtication and functional impairment, but also an experience of the symptoms by which patients are inconvenienced in their daily life and for which they decide to pursue treatment. From this trend, we note that the concept of scarring has expanded in different directions from the initial view considering scarring to be a simple visual defect (Fearmonti et al., 2010). Surgery, burns, wounds, and inflammatory processes can lead to the development of a variety of scars. Scars can be hypertrophic, keloid, atrophic, and acne scars. Once the scar has formed it undergoes several distinct macro- and microscopic changes during the maturation process and is complete on average after 1 year (Bond et al., 2008).

Medical management of atrophic scars can be done by using topical retinoids. Surgical management

can be done using punch excision, elliptical excision, punch elevation, skin grafting and subcision depending on the type of scar. Procedural management includes microdermabrasion, chemical peels, percutaneous collagen induction by microneedling and dermabrasion. Various ablative and nonablative lasers and light energies are also available for treatment of atrophic acne scars (Garg and Baveja, 2014). Others may include tissue augmentation by fillers or fat grafts. The most recent is radiofrequency and the fractionated radiofrequency (Peterson et al., 2011). Topical treatments are recommended by some and discouraged by others in a first approach to such line of prevention in scars treatment (Goodman, 2011).

Fractional resurfacing is a laser treatment modality that Manstein and colleagues introduced in 2004, to bridge the gap between ablative and non ablative resurfacing. Fractional resurfacing lays down a

matrix of energy beams to form an array of microscopic thermal wounds (microscopic treatment zones) to stimulate a therapeutic response in the dermis (Lapidot et al., 2014). Brief exposure to high energy results in tissue ablation that is sufficiently rapid to limit extracutaneous dermal injury. The reservoir of spared skin allows rapid repair of laser-induced injury (Park et al., 2015). Although fractional resurfacing does not produce results comparable with those of full ablative laser skin resurfacing, it has quickly become much more popular than the latter because the side effects, risks, and down-time of treatment are limited and improvement is acceptable (Naouri et al., 2011). The aim of this study is to assess the safety and efficacy of treating atrophic scars using a fractional CO₂ laser.

Patients and Methods

This study was carried out on 30 patients with Fitzpatrick skin types III-IV aged 18-44 years, with mean age of (23.77 ± 6.63 years). There were 14 (46.7%) males and 16 (53.3%) females. 14 patients had atrophic acne scars (46.7%) and 16 patients had post traumatic atrophic scars (52.3%). All patients were informed about the nature of the procedure and were requested to sign a written informed consent that was approved by the Ethics Committee of Human Research, Benha University. Inclusion criteria included males or females between the age of 18 – 60 years. Atrophic scars (atrophic acne, post varicella and depressed scars due to cut wounds or surgical incisions) Skin type II-IV and a duration of the atrophic scars 1 year or more. Exclusion criteria included a tendency to produce hypertrophic scars or keloids, previous treatment of the study area with dermabrasion, chemical peeling, filler, laser treatment or intense pulsed laser. Photosensitivity, pregnancy or lactation, active local or systemic infection and the use of oral retinoid drugs within the past 6 months. Before any procedure, the treatment area was cleansed of sebum and debris (including dirt, makeup, and powder) using a mild cleaner and 70% alcohol. A thick layer of EMLA 5% cream (lidocaine 2.5% and prilocaine 2.5%; AstraZeneca) was then applied to the treatment site for 2 hours prior. Before starting the procedure, the cream was removed with dry gauze and the treatment site was once more cleaned with an antiseptic solution. Both the patients and the operators wore safety goggles during the laser session.

Treatment was then applied to the lesion and 2 mm of the bordering unaffected skin using a 10,600 nm fractional CO₂ laser (SmartXide DOT (DEKA) ITALY 10600 nm is the fractional CO₂ laser device used in this study. This fractional laser delivers a laser beam in a punctate pattern (spot size 0.12 mm) which vaporizes the epidermis and part of the dermis promoting collagen contraction via its thermal effects, thereby inducing skin remodeling.

Different settings were used according to each individual case regarding the type of scar, severity and skin type. In an attempt to avoid common side effects that occur with fractional laser treatment, a lower fluence was used in the first session and depending on the results, the fluence was increased per treatment session. The irradiation fluence (J/cm²) is determined by a combination of four parameters, power (output), dwell time (pulse width), dot pitch (distance between irradiation points) and smart stack level. The "Smart Stack Mode" is an additional parameter which repeats the laser pulse in the same DOT for a maximum of five times before moving on to the next one increasing the thermal effect. A 1.5-cm square was irradiated by the scanning mode using the stamping and rolling.

Cooling using ice-packs was performed immediately after the procedure to reduce pain.

After irradiation, the treated area was sufficiently cooled with icepacks. Sun protection 50 spf was prescribed as well as topical antibiotic Gentamicin 2% ointment. The ointment was applied for 7 days as conservative precaution to prevent bacterial infections and provide a suitable environment for wound healing. Only two acne scars and two depressed scars patients received topical Betamethasone valerate/ Fusidic acid cream. Only two patients were prescribed oral Doxycycline, one week prior to treatment at dose of 100 mg twice daily for one month duration. No other patients were prescribed topical corticosteroids in this study. All patients were strictly advised to avoid direct sunlight for 4-5 days post laser treatment and to refrain from premature peeling of the treated area (Loesch et al., 2014).

Patients were treated with a total of three sessions at 1-month intervals. Follow up occurred one month after each treatment session. All patients were photographed before and after treatment sessions as well as 1 month post treatment session using iPhone 5 S camera (Tanzi and Alster, 2004). Post-treatment erythema and edema as well as improvements in texture, atrophy, and overall appearance were graded by the investigator on a quartile scale (poor, ≤25% = minimal to no improvement; fair, 26–50% = moderate improvement; good, 51–75% = marked improvement; and excellent, >75% = near-total improvement). Two blinded dermatologists assessed the treatment response by comparing pretreatment and post-treatment clinical images using the same quartile grading scale (Nouri et al., 2008).

A subjective assessment was also performed by the patients in terms of their overall satisfaction with appearance using a five-point scale (grade 0, no improvement = dissatisfied; grade 1, 1–25% = slightly satisfied; grade 2, 26–50% = satisfied; grade 3, 51–75% = very satisfied; grade 4, 76–100% improvement = extremely satisfied). Patients

were also asked to grade pain during the procedure on a four-point scale (0 = no pain; 1 = mild pain; 2 = moderate pain; and 3 = severe pain).

Statistical Analysis

Results were analyzed using the IBM SPSS statistics software version 20 (Statistical Package for Social Sciences). Nonparametric statistical methods were used for data. Data Analysis was presented as Friedman Test (Chi-Square) for comparison of the three sessions. Data Analysis was presented as Mann–Whitney U test for comparison of the two scar types. The Spearman correlation was used to show the bivariate relationships between two variables. The t-test for equality of means was used to assess whether the means of two groups are statistically significant from each other. For all tests used, a difference with a 'P' value less than 0.05 ($P < 0.05$) was considered statistically significant and a 'P' value less than 0.01 was considered highly statistically significant HS; otherwise, it was insignificant NS.

Results

There was a total 30 patients aged 18-44 years, with mean age of (23.7667 ± 6.63 years). There were 14(46.7%) males and 16 (53.3%) females. There were fourteen patients (46.7%) with acne scars and sixteen patients (53.3%) with depressed scars. All patients underwent at least three sessions of treatment at 1-month interval. All patients tolerated the procedure with topical anesthesia (EMLA) for 90 min before the procedure with varying degrees of pain. There was a statistically significant difference in the patients pain sensation for both scar groups in this current study. Chart 1 shows the patients pain sensation varied over the course of treatment however most of the patients had mild to moderate pain.

Tables 1 and 2 show the improvement of skin texture for both scar groups. All patients showed some sort of clinical improvement according to the assessment of the investigator and the two blinded dermatologists. The skin texture of the acne scar and depressed scar group improved per treatment session. After completion of treatment there was a statistically significant difference for all dermatologists in their assessment of the improvement of skin texture for both scar groups between the three sessions. There was no statistically significant difference between the three dermatologists assessment.

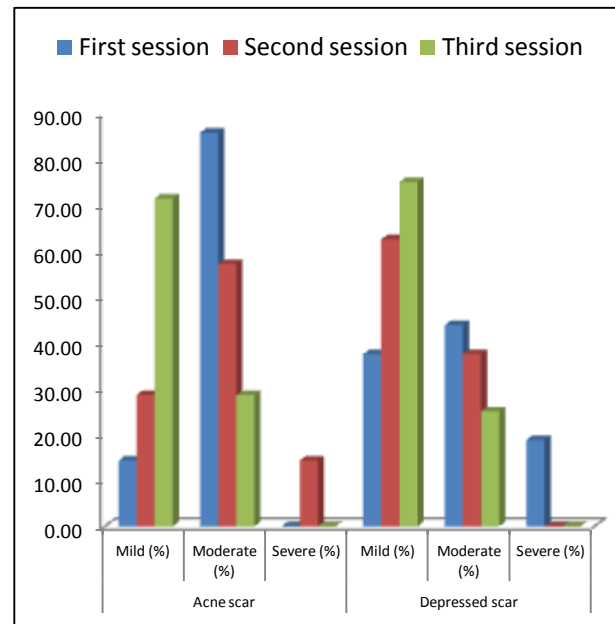


Chart (1): The pain sensation of the patients in both groups after each treatment session

Table 3 shows the overall scar appearance after the course of treatment. The acne scar group as assessed by the investigator showed 7.1 % with mild improvement, 50% moderate improvement, 28.6% good improvement and 14.3% excellent improvement. The depressed scar group showed 43.8% had mild improvement, 31.3% moderate improvement, 25% good improvement and none of the patients showed excellent improvement. There was a significant difference in the overall scar appearance between both scar groups according to all dermatologists. The acne scar group improved more than the depressed scar group. There was no statistically significant difference in the assessment of the three dermatologists in regards to the overall appearance of the acne scar and depressed scar group.

Chart 2 shows the participating patients satisfaction. After completion of treatment in the acne scars group, 5 patients were slightly satisfied, 2 patients were satisfied, 4 patients were very satisfied and 3 patients were extremely satisfied. After completion of treatment in the depressed scar group, 3 patients were not satisfied with the outcome, 6 patients were slightly satisfied, 6 patients were satisfied and only 1 patient was extremely satisfied.

There was no significant correlation between age of patient and clinical improvement for both scar groups. There was however a statistically significant difference in the overall scar appearance of the acne scar group in relation to their sex. According to the investigators assessment the males of the acne scar group showed better improvement than the females; however, for the depressed scar group there was no significant

difference in the overall scar appearance in relation to their sex.

Fig. 3, Tables (4 and 5) elaborate on the fluence levels. In this study, we attempted to examine whether higher or lower fluencies yield superior results in the treatment of atrophic scars. There was no statistically significant difference in the fluencies used between the acne and depressed scars groups for all sessions. There was a statistically significant difference in the fluencies used between the three sessions for the acne scars group and depressed scar group. There was positive statistically significant correlation between the fluence used in the third session and the improvement of skin texture for both scar groups.

Side effects were minimal and transient, including transient edema, erythema and crust formation. No permanent hyper- or hypopigmentation were recorded. No pruritis or petechiae or any other side effects.

Discussion

The demand for skin resurfacing and rejuvenating procedures has progressively increased in the last decade and has sparked several advances within the skin resurfacing field that promote faster healing while minimizing downtime and side effects for patients. Several technological and procedural skin resurfacing developments are being integrated into clinical practices today allowing clinicians to treat a broader range of patients' skin types and pathologies than in years past, with noteworthy outcomes Loesch *et al.*, (2014).

Atrophic scars are dermal depressions that generally occur as a result of collagen destruction during an inflammatory skin disease such as cystic acne or varicella Tanzi *et al.*, (2004). Surgery and trauma can also result in the formation of atrophic scars. Most patients attempt to camouflage these pitted lesions with make-up, but their appearance is often exacerbated by make-up due to its enhancement of the textural variation Nouri *et al.*, (2008).

All of the patients that participated in this study were Fitzpatrick skin type III- IV. Goel *et al.*, (2011) confirmed the suitability and safety of fractional resurfacing for darker skin types. Ciocon *et al.*, (2013) also reported that the side effect profile and clinical effect were shown to be similar between different skin phototypes and recommended the use of fractional skin resurfacing in patients with darker skin phototypes.

In terms of the evaluation of skin texture of the acne scar group there was a statistically significant difference between the three sessions and this was in agreement with Saryazdi and Mohebbi, (2012) who performed three sessions of fractional CO₂ laser on 15 female patients with acne scars. They also recorded that all patients felt an ascending improvement rate during the course of treatment.

In the current study there was a statistically significant difference for acne and for the depressed scar between the three sessions in terms of patient satisfaction. The acne scar patients were more satisfied than the depressed scar group after second and third session.

In the current study there was a statistically significant difference in the overall scar appearance between both scar groups according to all dermatologists. The acne scar group showed better clinical improvement than the depressed scar group, however both scar groups showed improvement compared to baseline. Furthermore there was a statistically significant difference in the overall scar appearance of the acne scar group the males showed greater improvement than the females

Huang, (2013) performed at least two sessions with a fractional CO₂ laser spaced one month apart on 44 Chinese patients with acne scars. Some of his patients noticed the obvious change at scar depth after the first treatment. Sixty-four percent of the patients reached an overall improvement of 50–75 % after more than two treatment sessions. An average of 52.5 % improvement was achieved in this acne scar group and this was agreement with this study. The investigators assessment showed an average of 42.9% of patients showed good to excellent improvement was achieved in the acne scar group. Only 7.1 % of patients showed mild improvement, 50% moderate improvement, 28.6% good improvement and 14.3% showed excellent improvement compared to baseline at one month follow up post treatment.

A study was performed by Weiss *et al.*, (2010) to investigate ablative fractional laser CO₂ which included 15 patients with atrophic scars occurring as a result of post-operative or post traumatic. They observed an improvement in all scar variables after the first treatment and subsequent treatments resulted in incremental improvement in all variables. For treated scars, maximal benefit was appreciated 3 to 6 months after the final treatment. Each scar received 3 ablative fractional resurfacing treatments at 1- to 4-month intervals; at six month follow up investigator assessment was graded as 16% of the treated scars achieving excellent 76% or greater overall improvement and 89% of treated scars achieving 51% or greater overall improvement. In the present work, at 1 month follow up 43% showed mild improvement, 31.3% moderate improvement, 25% showed good improvement and none of the patients showed excellent improvement. This would explain why our results for the depressed scar group were not as impressive as the last follow up was only 1 month after final treatment. They also observed that improvement followed the first treatment, and subsequent treatments lead to incremental improvements in scar appearance.

One of the studies done by Park *et al.*, (2013), sought to determine appropriate initial start timing of nonablative fractional laser treatment of scars. They concluded that early treatment (i.e., within 3 weeks) was more effective than delayed treatment (i.e., within 3 months or within 6 months). Several studies by other institutions (Kim *et al.*, (2012); Ohshiro *et al.*, (2013) and Anderson *et al.*, (2014) examined the appropriate period of time to start laser treatment for facial lacerations and concluded that early treatment is more effective.

The changes in erythema and pigmentation for both scar groups were assessed. According to the investigator and both blinded dermatologists there was a statistically significant difference in the evaluation of changes in erythema and pigmentation between the three sessions for acne scar group. This was in agreement with Ozog *et al.*, (2013) reported clinical improvement in both hyperpigmentation and erythema over the course of treatment. They speculated that the improvement may be related to the histological improvement in the appearance of superficial blood vessels. The vessels within the remodeled collagen now lie in both perpendicular and parallel lines resulting in less vascular trapping. Moreover, Cho *et al.*, (2009) reported the synergistic fashion of ablative fractional laser and that it was very effective and safe for Asian patients with acne scarring. The superficial treatment with Active FX mode helped to improve erythema and pigmentation. For the depressed scar group there was a statistically significant difference between the three sessions according to the two blind dermatologists. The investigator assessment was non significant. This could be explained because the assessment of the blinded dermatologists was based on digital photographs and not by physical clinical assessment.

There was a statistically significant difference in the patients' pain sensation for both scar groups in this current study. The patients pain sensation varied over the course of treatment however, all patients had mild to moderate pain indicating that fractional CO₂ laser novel and safe device and was tolerated by all patients and this was in agreement with Chan *et al.*, (2007).

In this study we found that there was no statistically significant difference in the fluencies used between the acne and depressed scars groups for all three sessions however, there was a statistically significant difference in the fluencies used between the three sessions for both scar groups. There was a positive significant correlation between the fluencies used in the third session and the improvement of texture of both scar groups. This was in agreement with Shim *et al.*, (2015) whom performed a study on 57 patients with facial laceration scars in the early postoperative with a 1,550nm Fractional Erbium-Glass Laser. A total of four sessions were performed. In their research the

fluence used was assessed for both scar groups. There was no statistically significant difference between the fluencies used for both scar group however, a positive correlation between the fluence used and the improvement of skin texture for both scar groups was observed. This concurs that higher fluencies yields better results than lower fluencies. Moreover, Lin *et al.*, (2011) demonstrated that low density FNAR has similar clinical outcome as high-density FNAR. The study relies primarily on analyzing scars by blinded dermatologists using just a single modality of photography. Several subjects have higher-rated control side than the treatment side. Continuing scar remodeling could explain this phenomenon. The study includes subjects with a wide range of scar ages contrary to the current study in which scar duration was at least one year.

Adverse effects and complications related to fractional laser treatments were evaluated at all follow-up visits. Common adverse effects resulting from laser irradiation, such as the reactivation of herpes labialis, bacterial infections, postinflammatory, hyperpigmentation, dyspigmentation and outbreak of acneiform. Chan *et al.*, (2007) noted that patients with ethnic skin are at a very high risk of developing hyperpigmentation post treatment with fractional CO₂ laser. Even with non-CO₂ fractional devices, the patient should be treated with less aggressive settings to minimize this risk. The rate of PIH has been found to be directly proportional to both the energy and density of the treatment, although density appears to be particularly important. With this in mind we did utilize lower fluencies to avoid common complications. Cheyasak *et al.*, (2015) noted that postinflammatory hyperpigmentation (PIH) is the most common adverse effect of laser treatment in dark-skinned individuals. Little is known whether PIH can be prevented or minimized.

Conclusion and Recommendations

Owing to our results, fractional CO₂ laser represents a safe, well-tolerated, effective, and promising treatment modality for the treatment of atrophic scars, with minimal downtime and fewer side effects compared with the traditional laser resurfacing modalities. Fractional laser provides a wide range of treatment options that can be tailored to the individual's skin type and nature of the scar. Fewer treatment sessions result in a noticeable improvement, within a relatively shorter period of time. Larger clinical trials are required to assess the longevity of the improvement obtained. The ideal parameters for the best clinical outcome for scar treatment has yet to be determined. Future studies should investigate the optimal number of sessions or protocols for scars in different locations.

Table 1. Evaluation of the skin texture of the acne scars group after each session by the three investigators.

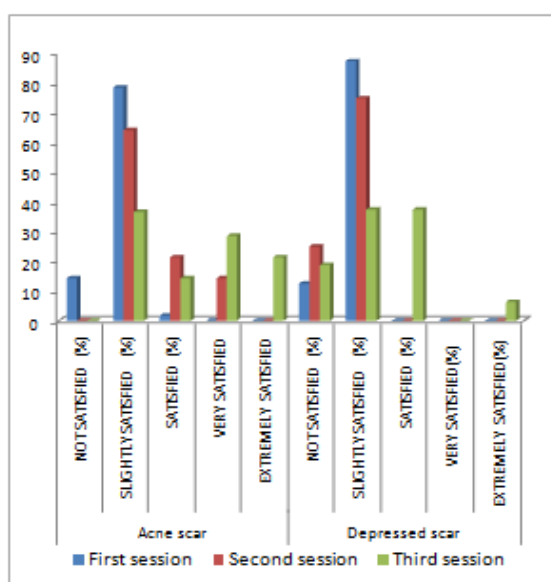
Session	Investigator**				First blind**				Second blind**				P value
	Mild n(%)	Moderate n(%)	Good n(%)	Excellent n(%)	Mild n(%)	Moderate n(%)	Good n(%)	Excellent n(%)	Mild n(%)	Moderate n(%)	Good n(%)	Excellent n(%)	
First	16(100)	0	0	0	16(100)	0	0	0	16(100)	0	0	0	1.000
Second	16(100)	0	0	0	16(100)	0	0	0	(92.9)	1(7.1)	0	0	0.368
Third	4(28.6)	6(42.9)	2(14.3)	2(14.3)	4(28.6)	6(42.9)	2(14.3)	2(14.3)	4(28.6)	6(42.9)	3(21.4)	1(7.1)	1.000
Overall Scar Appearance	1(7.1)	7(50)	4(28.6)	2(14.3)	1(7.1)	6(42.9)	6(42.9)	1(7.1)	1(7.1)	8(57.1)	4(28.6)	1(7.1)	0.56

Table 2. Evaluation of the skin texture of the depressed scars group after each session by the three investigators.

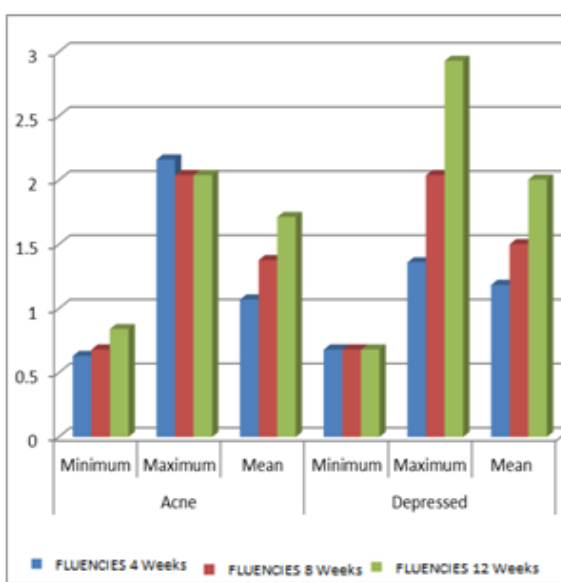
	Acne scar*				Depressed scar**			P value
	Mild n(%)	Moderate n(%)	Good n(%)	Excellent n(%)	Mild n(%)	Moderate n(%)	Good n(%)	
Investigator	1(7.1)	7(50)	4(28.6)	2(14.3)	7(43.8)	5(31.3)	4(25)	0.044
First blind	1(7.1)	6(42.9)	6(42.9)	1(7.1)	7(43.8)	5(31.3)	4(25)	0.033
Second blind	1(7.1)	8(57.1)	4(28.6)	1(7.1)	7(43.8)	5(31.3)	4(25)	0.042
Patient	3(21.4)	4(28.6)	5(35.7)	2(14.3)	6(37.5)	7(43.8)	3(18.8)	0.084

Table 3. Overall scar appearance among the two studied scar groups as assessed by the investigators and patients.

	Acne scar*				Depressed scar**			P value
	Mild n(%)	Moderate n(%)	Good n(%)	Excellent n(%)	Mild n(%)	Moderate n(%)	Good n(%)	
Investigator	1(7.1)	7(50)	4(28.6)	2(14.3)	7(43.8)	5(31.3)	4(25)	0.044
First blind	1(7.1)	6(42.9)	6(42.9)	1(7.1)	7(43.8)	5(31.3)	4(25)	0.033
Second blind	1(7.1)	8(57.1)	4(28.6)	1(7.1)	7(43.8)	5(31.3)	4(25)	0.042
Patient	3(21.4)	4(28.6)	5(35.7)	2(14.3)	6(37.5)	7(43.8)	3(18.8)	0.084



(Chart.2) Patient satisfaction recorded one month after previous treatment for both groups



(Chart.3) Comparison between the fluencies used per treatment session for the both scar groups

Table 4. Comparison between the fluencies used per treatment session for the both scar groups

Sessions	Acne scars			Depressed scars			P value
	Minimum	Maximum	Mean \pm SD	Minimum	Maximum	Mean \pm SD	
FLUENCIES_4 weeks	0.63	2.16	1.0700 \pm .5624	0.68	1.36	1.1837 \pm .277	0.501
FLUENCIES_8 weeks	0.68	2.04	1.3771 \pm 0.4965	0.68	2.04	1.5013 \pm 0.480	0.493
FLUENCIES_12 weeks	0.84	2.04	1.713 \pm 0.45	0.68	2.93	2.0050 \pm 0.675	0.181

Table 5. Correlations between the fluence and the improvement of skin texture for both scar groups

FLUENCE USED IN THE THIRD SESSION		IMPROVEMENT IN TEXTURE
Depressed scar	Correlation Coefficient	0.731**
	P value	0.001
	N	16
Acne scar	Correlation Coefficient	0.826**
	P value	0.000
	N	14

P< 0.01

(Fig.1)


22 Year old patient with severe combined atrophic acne scars
Excellent Improvement 75-100%, Patient satisfaction:
Extremely satisfied.

(Fig.2)


19 Year old patient with combined acne scar types,
with severe atrophic depressions, erythema and
pigmentation. Excellent Improvement 75-100%,
Patient Satisfaction: Extremely satisfied.

(Fig.3)


23 Year old patient with severe combined atrophic acne
scars. Moderate Improvement 25-50%, Patient Satisfaction:
Satisfied.

(Fig.4)

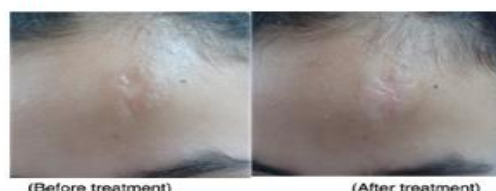

44 Year old patient with linear wide post traumatic
depressed scar. Good Improvement 51-75%, Patient
Satisfaction: Satisfied.

(Fig.5)



24 Year old patient with linear wide post traumatic depressed scar. Good Improvement 51-75%, Patient Satisfaction: Satisfied.

(Fig.6)



19 Year old patient with wide, post traumatic depressed scar. Good Improvement 51-75%, Patient Satisfaction: Satisfied.

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